Carbon Intensive Urbanization, Climate Variability and Urban Vulnerabilities in Hill Areas: A Case of Gangtok Urban Region, Sikkim

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Abstract

Rapid high carbon intensive urbanization is one of the important concerns in the environmental and global warming debates in the context of environmentally fragile and sensitive areas like the Himalayas. Rapid urbanization and urban growth leads to rapid destruction of green infrastructure, high emission of GHG from transportation, construction, manufacturing and associated sectors. High waste generation and improper management and disposal of the waste further aggravate the problem. The ecological footprints of supplying food and basic services like water along with the destruction and deterioration of other eco system services makes the urban areas vulnerable to hazards and climate impacts both in the short and the long term. The problems get further accentuated because of poor regional and urban planning practices and weak implementation of planning bye laws and development control regulations. All these have significant impact on the local climate, including heat island effects leading to increased variability and intensity of rainfall, temperature and humidity. As a result the urban areas become more vulnerable to hazards, disasters and epidemics and disease. Under such circumstances vulnerability mapping and evolving response and coping mechanism by internalizing them in sustainable habitat planning and development practices becomes important. Taking action to mitigate the problem is important but equally important is to evolve adaptation strategies which are locally conducive. The paper intends to understand these issues with respect to Gangtok Urban region using the available census and other statistical information. Attempt has been made to understand the weather, climate variability over the last few decades in the region and document the history of hazards and disasters through secondary literature. The study also focuses on the impacts of rapid urban growth on the local environment and its impact on eco system services. To what extent planning and urban management practices have tried to address these concerns have been explored by reviewing existing plan documents, bye laws and their implementation mechanism. Based on these analyses the study highlights vulnerabilities in Gangtok urban region and suggest coping mechanisms and strategies at the local and state level to address urban vulnerabilities in Sikkim.
Key words: Urbanisation, urban planning, hill development, climate variability, urban vulnerability, heat island, city resilience, adaptation framework, sustainability.

1. Introduction

Rapid and unplanned urbanization is one of the principal concern in the environmental degradation and global warming debates in environmentally fragile and sensitive areas like the Himalayas. Urban sprawl and urban expansion lead to rapid destruction of green infrastructure, high emission of GHG from transportation, construction, manufacturing and associated sectors (UNHABITAT, 2011). High waste generation and improper management and disposal of the waste further aggravate the problem. The ecological footprints of supplying food and basic services like water along with the destruction and deterioration of other eco system services make the urban areas vulnerable to hazards and climate impacts both in the short and the long term. The problems get further accentuated because of poor regional and urban planning practices and weak implementation of building bye laws and development control regulations. All these also impact on the micro climate including heat island effects. More importantly the unaddressed environmental problems get magnified in the event of climate change and variability impacts increasing the risk and vulnerability of the community. Urban areas become more vulnerable to hazards, disasters, epidemics, disease and other associated risks. Under such circumstances vulnerability mapping and evolving response and coping mechanism by internalizing them in sustainable habitat planning and development practices becomes important (Pelling, 2003). Taking action to mitigate the problem is important but equally important is to design adaptation strategies which are locally conducive (The World Bank, 2010). Local adaptation strategies are important because the social meaning of climate change varies across regions and cultural realms (Hulme, 2009).

It is in these contexts the paper will explore the nature and pattern of urbanization in Sikkim, the existing urban environmental condition and its' linkages in creating urban vulnerability due to climate variability as being witnessed in the region. The paper ends with few strategies to address emerging urban vulnerabilities in the region.

2. Methodology

The study is premised on the fact that high carbon intensive urbanization is unsustainable in hill areas even if the urbanization levels are low. Understanding climate induced vulnerability has to be placed in the context of larger developmental strategy and existing environmental condition. Climate induced vulnerability and risk will be high in areas where other form of environmental degradation is already high. It is also premised that vulnerability assessment has to be understood in the context of multiple hazards and risk especially in areas like the Himalayas which are exposed to more than one type's disaster and hazards. Hill towns like Gangtok experience earthquake, landslides, cloudburst, high speed wind and occasionally other climate induced extreme events. Internalizing the risks will have to be attempted appropriate mitigation and adaptation strategies which will have to be part of the larger policy planning at the state level and local action plans. Regional plans, local urban plans will have to be prepared based on scientific methods and framework.

Primary and secondary data have been collected through field studies for understanding environmental, urbanization and climate issues. Gangtok as a case has been given primary importance in establishing link between environmental degradation, climate variability and urban vulnerability. For understanding climate variability 35 years climatic data (1966-2000) have been analyzed with emphasis on temperature and rainfall variations in the region. Transportation sector has maximum impact on urban environmental pollution. Different methods have been used for calculating the future, up to 2030, vehicle growth and Volume/ Capacity ratios. Information for each ward was collected regarding travel pattern, modal split, travel distance and frequency of travel. Existing and future carbon footprint potential is calculated for Gangtok and its surroundings. The following method was used for calculating carbon footprint emission for Gangtok: $= A * B * C$ where, A= Total number of trips for households (mode wise, Trips for Work, Market and Shopping Purpose) B= Trip Length (mode wise) C= Emission factor (mode wise). Carbon footprint and carbon emissions are calculated at the ward level. Future population and projected trip length and model split were used to analyze the future emission scenario. The population for each ward is projected according to its economic potential and capacity to accommodate the future growth. Other environmental indicators like waste handling capacity, destruction of green infrastructure and past incidence of hazards have also been analyzed. The paper ends with few specific recommendations which can be useful in reducing future urban vulnerabilities in Gangtok.

3. Nature and pattern of urbanization and urban growth in Sikkim

Gangtok is located in Sikkim which is India's least populous state (Map 1). In 2011 it had 607,688 inhabitants and density of 86 persons per square kilometer. Its' growth rate between 2001 and 2011 was 12.36 percent. The urban population constitutes 11 percent of total population. The sex ratio in the state is 889 females per 1000 males, with a total of 321,661 males and 286,027 females recorded in 2011. The per capita income stands at 11,356, which is one of the highest in the country.

Urbanization in the state of Sikkim has been unequal over the years. As per 2011 census there are 9 urban centers which accommodate a population of 151726. The east district has 4 urban centers which include Gangtok the capital of the state with a population of 98658 (Census, 2011). 79 percent of the urban population in the state is concentrated in the east district (Figure 1) of

Map 1. Location of Gangtok urban region

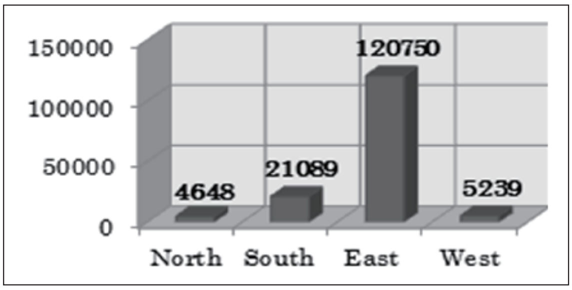


Figure 1. District wise population of Sikkim

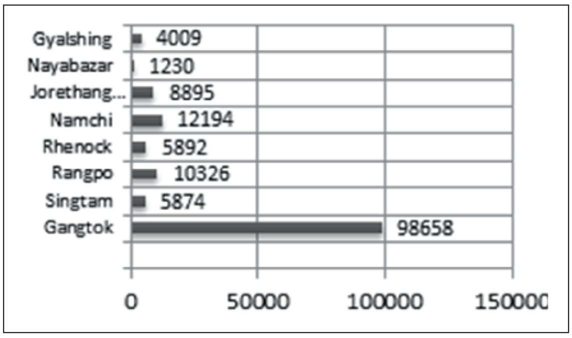


Figure 2. Population of urban centers of Sikkim

Source: Census data, own analysis

which 82 percent reside in Gangtok MC Area. Gangtok also indicates the highest growth rate along with greater population size amongst all the urban centers in the state and acts as a primate settlement (Figure 2).

The growth rate in the last decade has been highest resulting in 200 percent increase in population in the Gangtok urban region. This unprecedented growth has led to tremendous pressure on scarce urban resources including land leading to unplanned construction and frequent violation of building by laws and regulations. Rapid urban expansion has led to encroachment and development on unstable terrains and reduction of green areas. Besides land the overall environmental and infrastructural services has been overburdened and adversely affected. On the whole the increasing concentration of population and environmental degradation has led to increasing vulnerability of the habitat to disasters and hazards. Moreover weak governance framework, overlapping functional jurisdiction and changing municipal boundaries is also resulting in haphazard development in the periphery and weak coordination between institutions, hampering effective response to disasters.

The overall density of Gangtok urban region was 34 persons/ha. in 2008 but the core areas, ward no 12, 13, 5 reported a density of over 300 population/hactre. The density variation between the core and the periphery along various sections is indicated in Map 3. It can be clearly observed that along all the sections density increase in the core area is the highest. High densities along

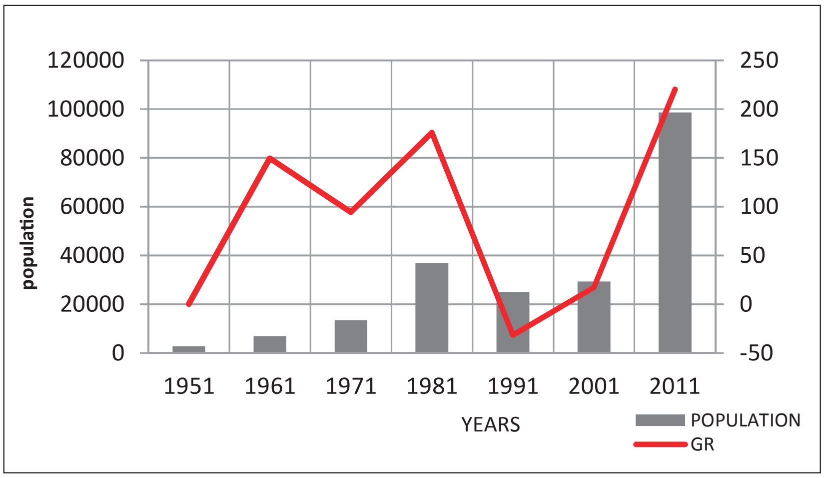
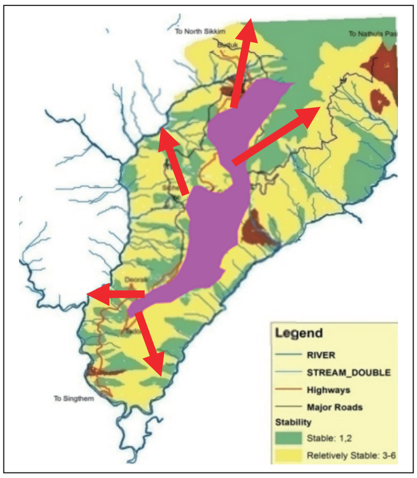
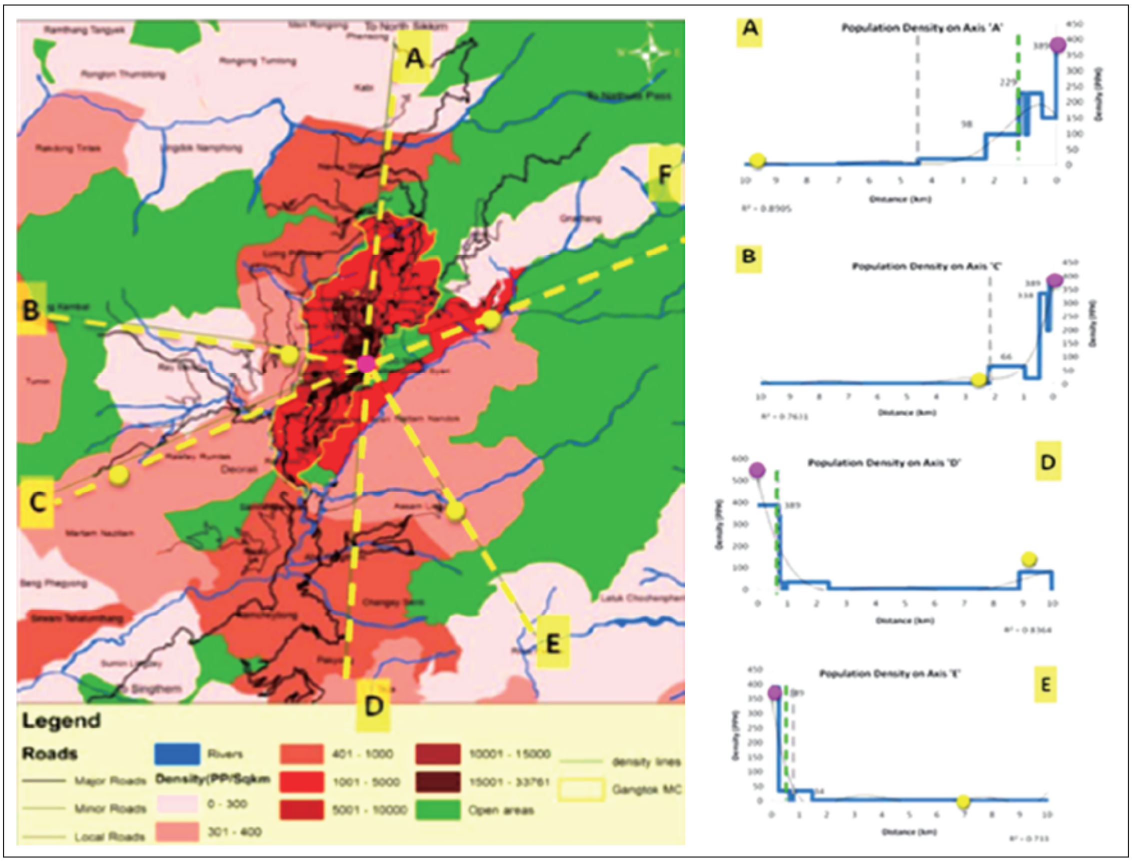


Figure 3. Population & growth rate in Gangtok MC area



Map 2. Urban growth over green steep surfaces



Map 3. Varying density in Gangtok urban region

with multi story buildings in the hilly areas are not conducive for land stability. High Density at the core also leads to higher energy emissions and increases heat island effect impacting the micro climate.

4. Urban footprints and emerging urban environmental problems in Gangtok and surroundings

Gangtok is also witnessing change in air quality and increase in GHG emissions. Generally the air quality in hill stations is supposed to be clean. But in case of Gangtok the pollution levels in many areas is a cause of concern. Although the situation is still not grave but this should be treated as one of the major future threat as the air pollution rate will continue to increase with greater level of urbanization, energy consumption and vehicular emissions. Local heat island effects, temperature inversion may worsen the situation.

Noise levels observed at important residential, commercial and silent zones indicate that ambient noise levels in most of the areas are above prescribed standards. Air and noise pollution in Gangtok urban region has increased significantly over the last few

Table 1. Air pollution levels in Gangtok urban region

Site Names	Category	SPM	SO_2	NO_x	Calculated index values	CPCB Index values	Description
Tadong	residential	108	16.2	15.7	1.04	0-0.5	clean air
Indira bye pass	commercial	137	17.4	22.6	1.3	0.5-1.25	low air pollution
Deorali	residential	118	18.6	16.1	1.14	1.25-2	moderate air pollution
Bazar area	commercial	145	22.3	20.4	1.4	2.0- 3.0	high air pollution
Hospital point	sensitive	122	19.6	18.6	1.21	>3	severe air pollution
Zero point	sensitive	98	10.2	12.3	0.85		

Note: CPCB is Central Pollution Control Board,
Source: Sikkim Pollution control board-2004-05

decades primarily due to increasing vehicular emissions, construction and increased energy consumption at the household level.

The extent of green cover has close relationship with the climatic pattern of a region. Rapid urbanization in the Himalayas has crept into the forest areas and green zones which may be affecting the regional weather and climate pattern. It has been observed that Sikkim and Assam the two prime states in the North East is showing high rate of forest depletion than other non Himalayan states. In case of Sikkim most of the forest degradation is probably associated with higher rate of urbanization as in the East District. Road and other construction activities including hydel projects are also important factors.

Table 2. Extent of degraded forests across states in million hectares between 1989-1999

State	1989	1991	1993	1995	1997	1999	Growth Rate
Sikkim	0.02 (9.1)	0.02 (9.3)	0.03(12.2)	0.02 (8.5)	0.02 (8.6)	0.03(10.8)	1.8
Assam	1.5 (48.9)	1.5 (48.4)	1.45(47.9)	1.5 (48.9)	1.5 (49.4)	1.6 (52.7)	0.75
Himachal Pradesh	1.4 (66.7)	2.9 (76.3)	2.6 (72.9)	2.6 (73.0)	2.6 (73.0)	2.6 (74.2)	6.33
Punjab	0.3 (96.5)	0.2 (83.1)	0.2 (83.4)	0.2 (83.4)	0.2 (82.4)	0.2 (82.2)	-1.26
Gujarat	1.4 (72.0)	1.3 (67.9)	1.3 (67.5)	1.3 (67.2)	1.3 (67.3)	1.3 (66.8)	-0.41
Kerala	0.3 (26.0)	0.3 (24.9)	0.3 (24.9)	0.3 (24.7)	0.3 (24.7)	0.3 (24.9)	-0.41

Source: Forest Survey of India, Ministry of Environment and Forests, Government of India, New

Infrastructure and environmental management practices often indicate the level of preparedness of the cities to adapt to vulnerabilities and climate change consequences. The higher is the level of city environmental management standards the lower is the urban vulnerability (Environmental management and urban vulnerability, World Bank- 1992). Hence it is interesting to analyze Gangtok from its existing environmental management practice for which sanitation and solid waste management has been taken as a benchmark.

The analysis (Figure 4) shows that only 40 percent of the households in the urban region are covered with waste water network which is below the standard. Although the waste water treatment capacity is good but the recycling and reuse is still not practiced. Survey indicated that solid waste management is poor, only 30 percent households are covered and waste collection efficiency is only 40 percent. Throwing of waste into “Jhoras” and roads (Figure 7) often pollutes the water and sometimes trigger landslides and slope failure

Poor environmental management practices are increasing the vulnerability and the city is not well prepared to combat the environmental change and related disasters at this moment. Effective infrastructure planning and improved environmental planning is needed to reduce the risk.

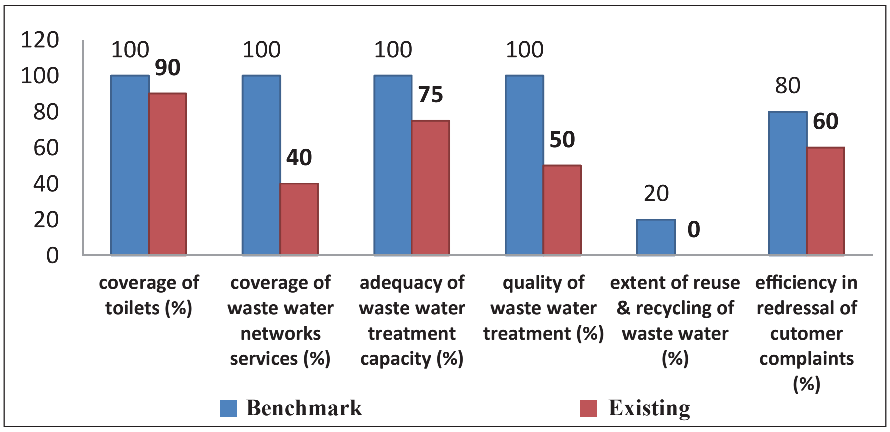


Figure 4. Status of sanitation in Gangtok MC area

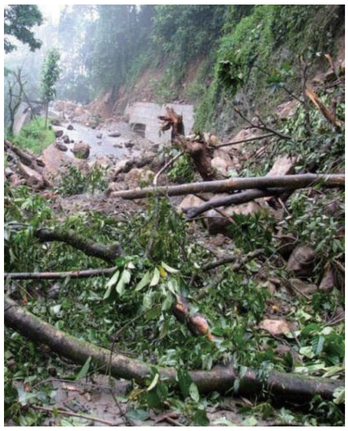


Figure 5. Deforestation along NH

Transportation sector has considerable impact on urban environment as the level of air pollution is directly linked with vehicle composition, volume and fuel type. Traffic composition, increase in vehicles and volume capacity ratio has been analyzed to understand the impacts of the sector on local environment. Public transportation in Gangtok is poor. The number of private vehicles registered in the last decade has increased quite significantly resulting in congestion and pollution.

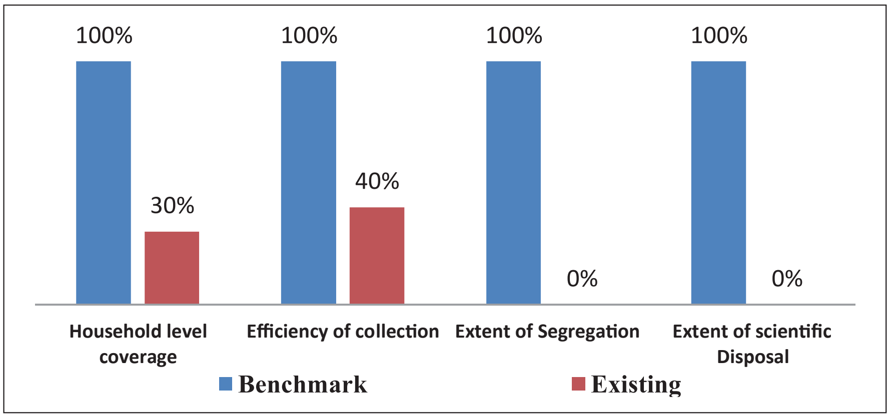


Figure 6. Status of solid waste management in Gangtok

Source: Gangtok Municipal corporation-2011

Figure 7. Waste dump at Jhoras

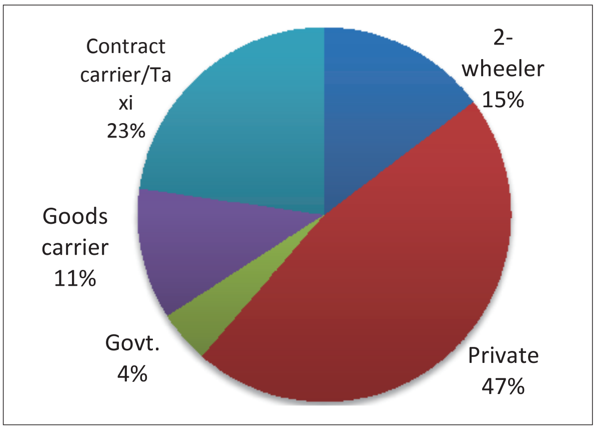
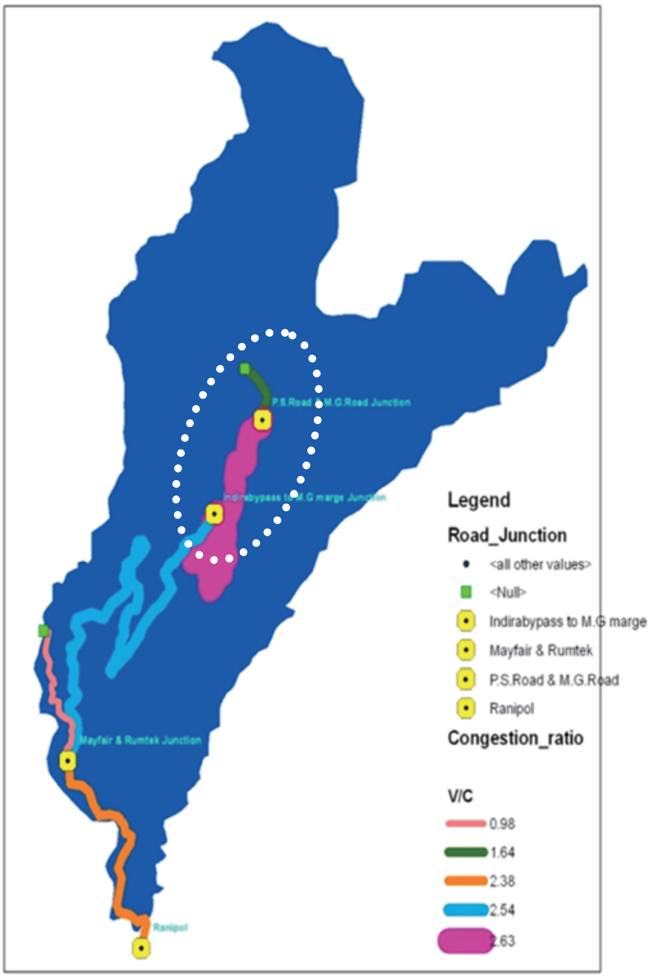


Figure 8. Traffic composition in Gangtok

Source: CEPT Environmental Planning Lab-2011



Map 4. V/C Ratio at selected stretches

Source: CEPT Environmental Planning Lab-2011

The velocity capacity ratio (Map 4) along major roads clearly indicates that the main commercial and institutional zones in central business areas have maximum traffic volume. Along with high commercial and residential densities emission will be maximum in the zone triggering heat island effects.

The projected scenario indicates that maximum emissions will be generated by private vehicles in the 12 km stretch between Ranipol to MG Marg. The vehicular growth and emissions and resultant carbon footprints have also been mapped. The prediction model clearly indicates that transport emission in the lower altitude like Ranipol will be higher than the areas like upper MG Marg at a higher elevation. The reason for high emission and pollution in the selected areas is due to narrow roads, central location, congestion and predominance of private vehicles in the stretches. If the same emission rate prevails then air pollution can become severe. Urban transportation planning interventions therefore needs to emphasize public transportation and pedestrianization of all major roads.

The carbon footprint data has been calculated for the transport sector which indicates pollution load from different modes. The carbon footprint was being calculated for the transport sector. The data for each ward was collected regarding their travel pattern, model split, travel distance and frequency of travel. The calculated carbon footprint will help analyse the ward emitting maximum carbon and the modal split. Thus modifying or changing the modal split would help to reduce the emission of the

Gangtok region. The emissions were ultimately converted in GWP (Global warming potential).

Method Used for calculating carbon footprint Emission Estimation for Gangtok: = A * B * C Where, A= Total number of trips for households (mode wise) (Trips for Work, Market and Shopping Purpose) B= Trip Length (mode wise) C= Emission factor (mode wise).

Table 3. Emission factor for each model split, CPCB

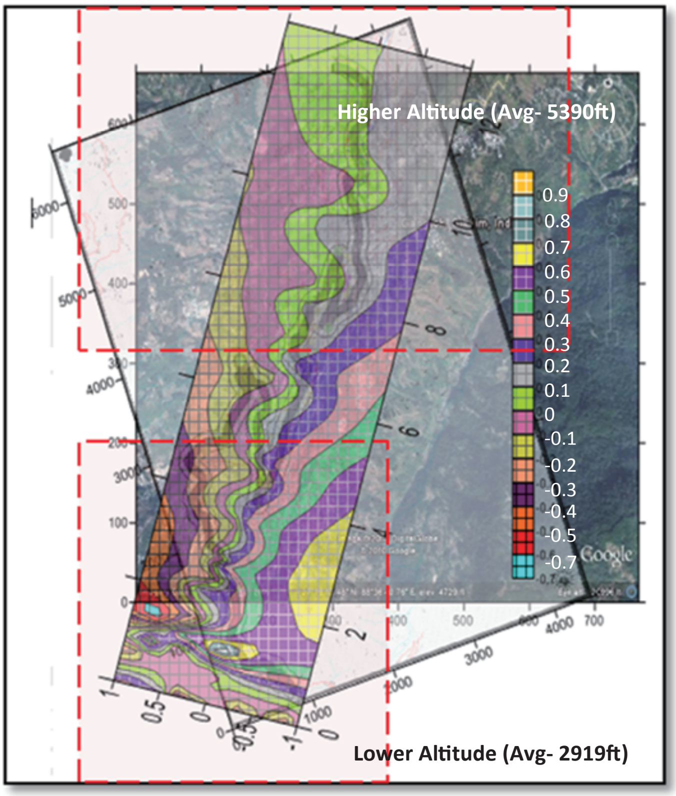
Type of Vehicle	CO	NO_x	$HC+NO_x$	HC	CO_2	PM
Two wheelers	2	2	0.5	6	27	0.05
Tour wheelers	5	3.3	133	2	220	0.14
Auto	1.5	0.2	1.33	1.5	25	0.014
Bus	5	13	2	2	500	0.2

Source: CEPT Environmental Planning Lab-2011

Table 4. Emission standards for each gas by GWP

Total emission	GWP Factor
NO_x	289
$HC+NO_x$	21
HC	21
CO_2	1

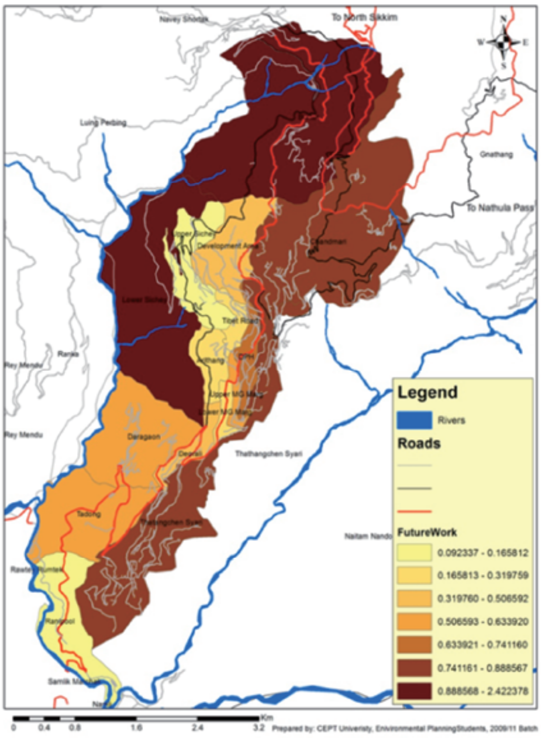
The **total number of trips** for each household were carried though Primary Survey of Household (Ward Wise). 10% sample was taken for each ward and then the collected data was computed for the total ward-wise population. Thus the total number of trips generated by household per day was analysed from each ward. The **Trip length** for each individual was calculated by analysing Distance travelled by household for Work, Market and Shopping purpose (Mode-wise). Emission factor plays an important role to calculate the carbon footprint. Emission factors for different modes were collected as guided by CPCB.



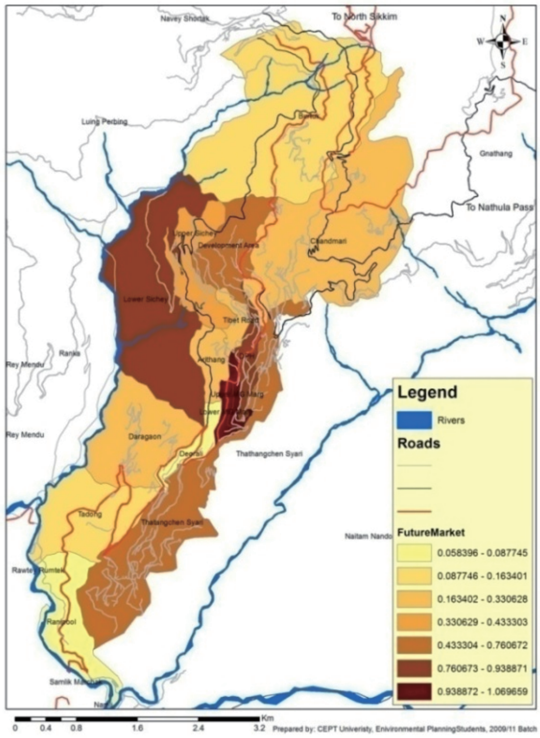
Map 5. Forecast models for carbon footprint, Gangtok-2031

Source: CEPT Environmental Planning Lab-2011

The maps (6) depicts that the existing carbon emissions and local heat island potential is maximum in the central and north eastern part of the urban region which is basically due to trips for working and market/shopping. When the same is forecasted for 2030 it is observed that northern and central part of the region will be the worst affected areas. But with technical interventions and planned development 10-31 percent of the emission can be reduced by 2030.



Map 6. Global warming potential: Trips for work purpose, 2030



Map 7. Global warming potential: Trips for market purpose, 2030

A comparison (Table 5) of different variables between hill capital cities indicates that Shimla is better off than Gangtok. There is enough scope to increase public transport, parking, reduce accidents and improve road safety in Gangtok which will help in reducing vulnerability in the urban area.

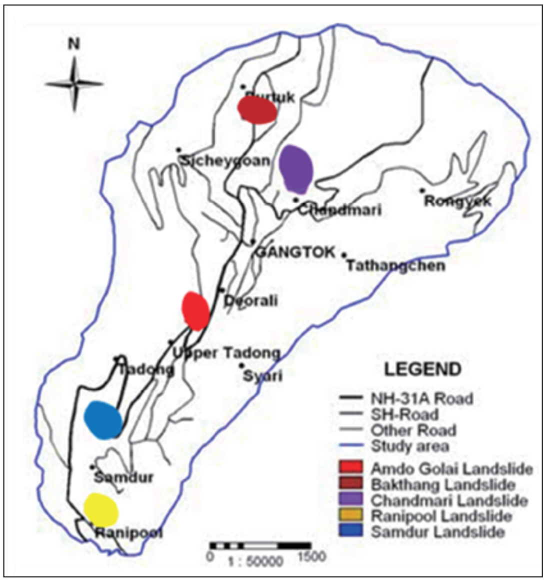
Table 5. Parameters of transportation standards: A comparison

City	Area (sq km)	Population (in lakhs) 2001 census	Total No. of city buses 2007	City bus transport supply index	Public Transport accessibility Index	Congestion index	On-street Parking Interference index	Total accidents/ lakh pop	Safety index	Transport performance index
Gangtok	77	0.92	Nil	0	0	0.21	0.59	**177**	0.04	202
Shimla	100	1.73	16	**8.66**	0.7	0.13	0.54	90	**0.06**	237

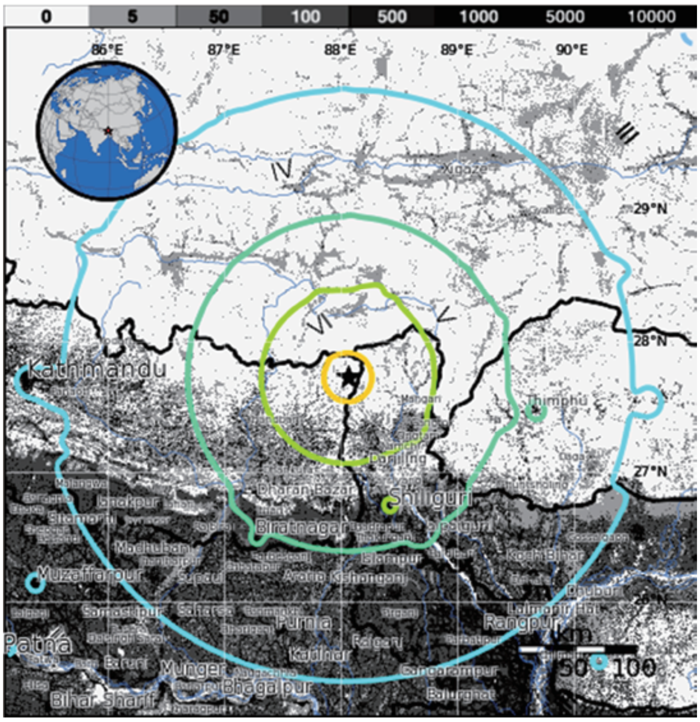
Source: CEPT Environmental Planning Lab-2011

5. Growing incidents and impacts of hazards and disasters

The natural geological setting of the Himalayan region is such that is often affected by earthquakes of varying intensity due to the constant movement of Indian and the Eurasian plate. Unplanned urbanization, rapid construction on hill slopes and no development zones along with climate variability in the region has further aggravated the problem and increased the risk.



Map 8. Landslide map of Gangtok MC area



Map 9. Earthquake affected areas in 18th September-2011

Source: http://www.usgs.gov/

The18th September, 2011 earthquake in the region represents the gravity of the challenges lying ahead. Map 8 represents the earthquake affected areas and epicenter of the 6.9 magnitude disaster. It can be clearly observed that Gangtok was well within first layer of destruction.

Table 6. Events of landslides in Gangtok

Date & Year	No of Killed	Location
June 20,1990	1	Bojoghari Gangtok
Sept 16,1990	37	Syari, Gangtok
May 10,1991	148	Chandmari,Gangtok
June 5,1995	26	Deorali, Gangtok
Oct 2,1996	9	Luing
Oct 2,1996	1	Zero Point Gangtok
May 24,1997	7	Saokhola, Rangli
June 8,1997	48	Gangtok
June 10,1998	2	Rumtek
Sept 25,2005	3	Rakdong

Source: GIS section, PWD department-UD& HD, Sikkim

Weak geology, slope instability, frequent seismicity coupled with the variable and high rainfall, soil erosion and unplanned growth has lead to occurrence of several landslide in Gangtok Urban region(Table 6, Map 8). Most of landslide prone areas are located side along the NH where major urban development and construction activities are taking place.

Although the number of landslide events has increased over the years but the frequency of tremor during landslide have decreased. This is due to the fact that the landslide events in the last two decades have occurred mostly due to local reasons in the form of increasing soil instability due to widespread construction, unplanned developments etc. Although these incidents are localized and are not of high magnitudes but have widespread effects in the form of house and infrastructure damage, road blockage etc.

Figure 9. Landslide phenomenon in Gangtok

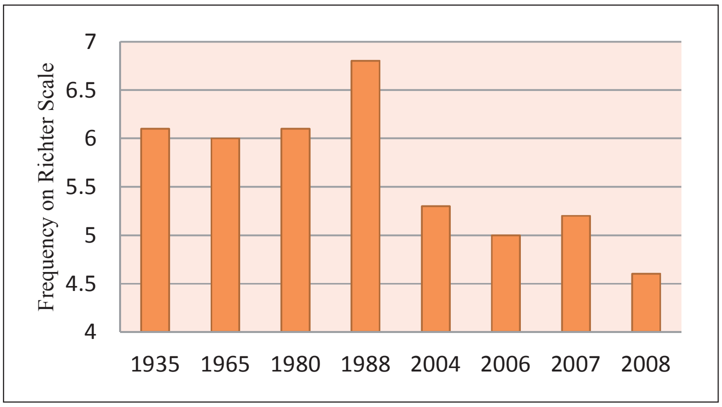


Figure 10. Frequency of landslide disasters- Gangtok

Source: GIS section, PWD department-UD& HD, Sikkim

6. Changes and variability in weather and climatic pattern in Gangtok

Temperature data for 35 years 1966-2000 have been analyzed to understand the climate variability scenarios in Gangtok urban region. The annual mean maximum temperature[1] pattern shows an overall decreasing trend with major fluctuation and increasing trend over the last decade. Although the changes observed is minor but the consequences are uncertain and risk unpredictable.

The annual mean minimum temperature[2] in Gangtok has increased consistently over last three decades (Figure 12) due to increased construction and lessening ground absorption, greater emissions as a result of increasing vehicles etc. This means there is

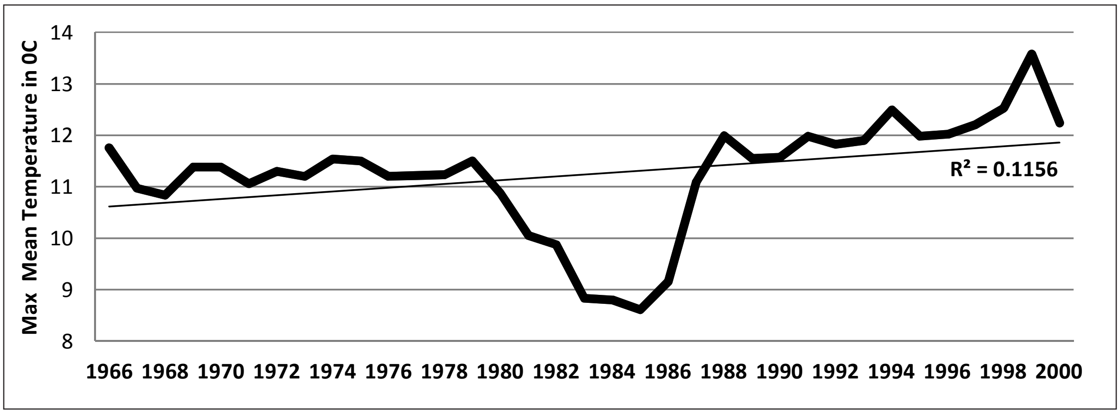


Figure 11. Annual mean maximum temperature- Gangtok

Source: Department of Meteorology, Govt. of India (1966-2000)

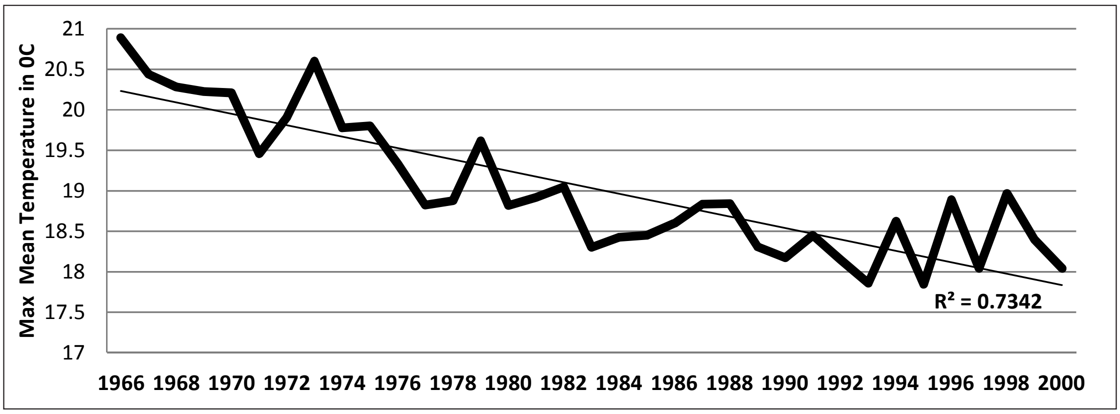


Figure 12. Annual mean minimum temperature- Gangtok

Source: Department of Meteorology, Govt. of India (1966-2000) an increase in temperature in winter season in the region which can lead to greater rate of glacier melting at the higher altitude and increased riverine flows and floods in the lower catchment areas.

The gap between minimum and maximum temperature is decreasing over time. Decrease in mean maximum temperature and reducing gap between maximum and minimum temperature will impact energy demand for various needs including heating. Temperature reduction during day time also may affect vegetative cover. This poses threat to the urban region of Gangtok and its surrounding area.

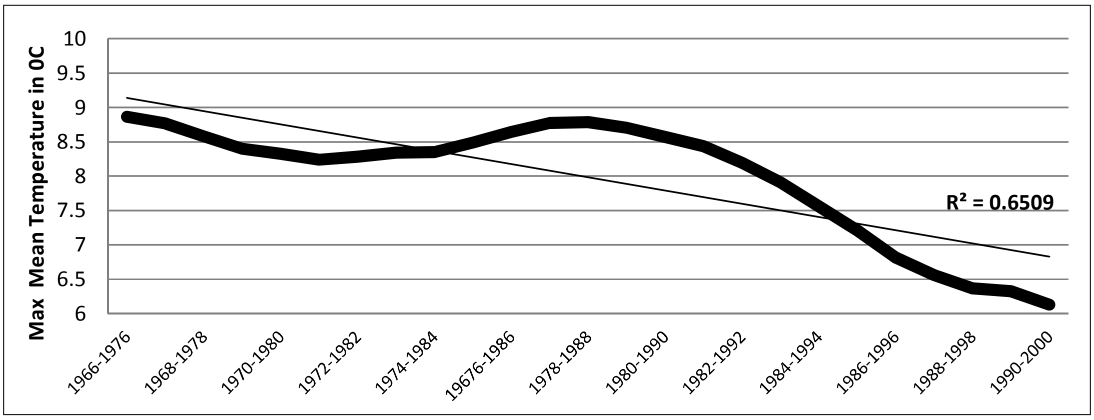


Figure 13. Decadal moving average of the gap between mean minimum & maximum temperature- Gangtok

Source: Department of Meteorology, Govt. of India (1966-2000)

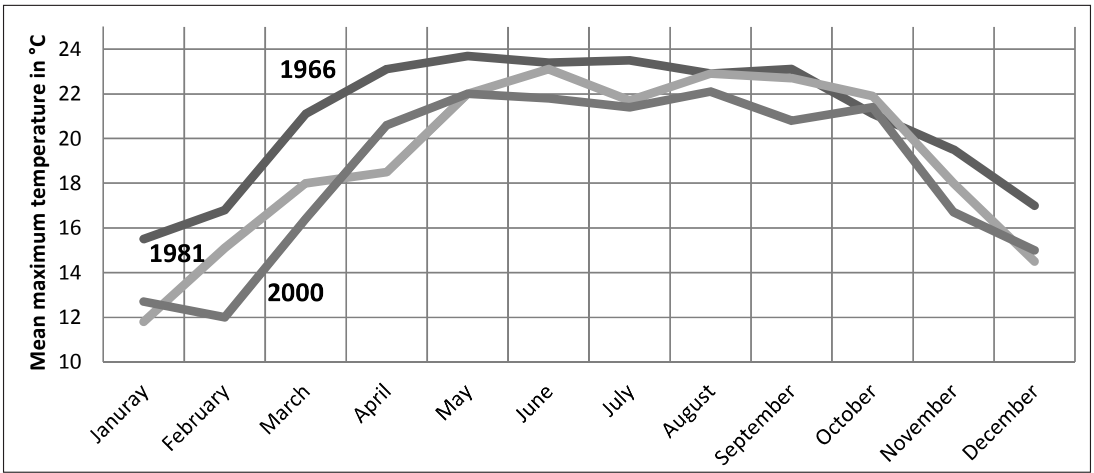


Figure 14. Variation in monthly mean maximum temperature in Gangtok

Source: Department of Meteorology, Govt. of India (1966-2000)

Fluctuations in mean monthly temperature over last three decades have also been witnessed. It can be easily inferred from the chart that in 1966 the changes in monthly mean maximum temperature was quite smooth and where as in 1981 and especially 2000 the curve shows abrupt change of temperature during summer season. The temperature during monsoon and post monsoon season shows greater fluctuations which can affect the monsoon rainfall in the region.

Variability and intensity of rainfall pattern may also impact water resources and trigger disaster and hazard pattern. The chart below shows decadal moving average of monthly rainfall in Gangtok which clearly indicates that the annual rainfall has reduced over the years in the area. Also the rainfall during monsoon season between the months of May to August has reduced as shown in the chart. It is difficult to ascertain the causes but local factors like rapid urbanization, increasing GHG emissions and changes in the temperature pattern in the region coupled with the effects of greater reduction in forest cover cannot be ignored along with global atmospheric phenomenon including the changes in the behavior of the south west monsoon. These changes can have significant impact on the regional hydrology affecting the ecological services like water supply to Gangtok city especially during the dry seasons from March to May. It can also affect the vegetation, bio-diversity of the region and supply of day to day necessities like vegetable, dairy products and other local food crops thereby affecting the food security and increasing the ecological footprints.

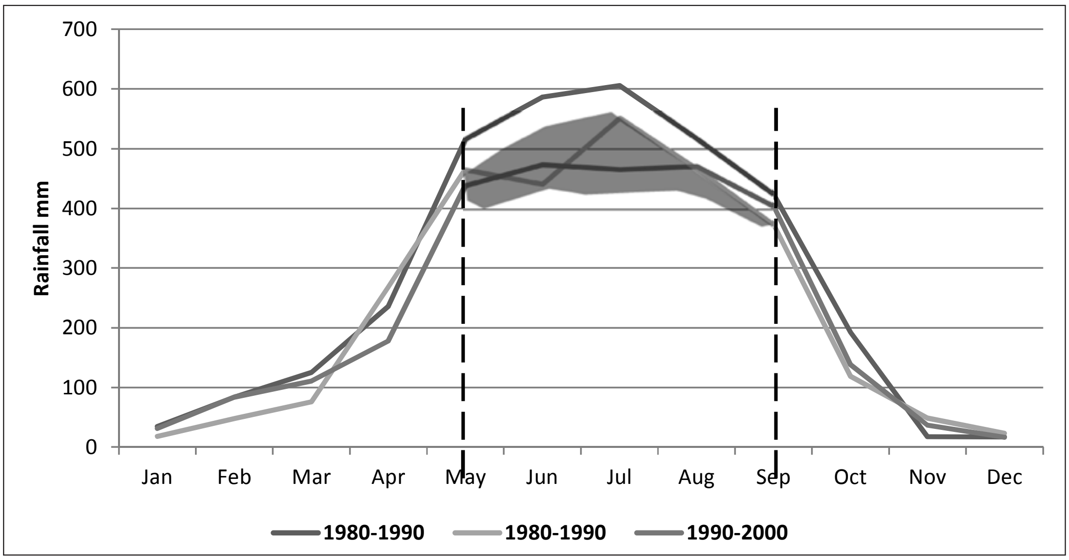


Figure 15. Decadal variation of monthly rainfall - Gangtok

Source: Department of Meteorology, Govt. of India (1966-2000)

Increasing climate variability as witnessed in the region may lead to increasing frequency of disasters in the region with adverse impact on human lives and property unless institutional capacity is built to take appropriate action to address the problem. Preparing land use plans and regional and sub regional plans and legal framework to implement such plans are important.

7. Emerging urban vulnerabilities in Gangtok and surroundings

Rapid economic development, changing environment and climate varaibility has increased the vulnerabilities of hill communities. It is therfore important to understand that the future impact of disasters on the life of the population of the region will depend on adaptation and preparedness level of communities and the Government. Vulnerability refers to degree to which people, property, resources, systems, and cultural, economic, environmental and social activity is susceptible to harm, degradation, or destruction on being exposed to a hostile agent or factor. In relation to hazards and disasters, vulnerability is a concept that links people with their environment. It's also the extent to which changes could harm a system, or to which a community can be affected by the impact of a hazard. Vulnerabilities can be simple (single) or multiple (Pratt et.al, 2004) in the context of hill areas with exposure to multiple hazard and climate variability identification of multiple vulnerabilities is important.

As indicated before the key factors that are responsible for increasing vulnerability potential of the region are unplanned high density developments, increase in traffic volume, violation of building codes, by laws and changing pattern of temperature, rainfall as well as poor urban environmental management practices.

8. Environmental and climate resilient planning interventions for Gangtok urban region

In the context of deteriorating environmental condition in Gangtok the following planning interventions are considered important.

Innovative public transport mechanisms have to be developed in the region for reduction of private traffic and thereby energy consumption and emissions. Due to lesser width of the roads in the hilly region smaller transportation system like public taxi (as seen in case of Shimla) can be adopted. Ropeways and lifts can also be used for transportation of tourists from lower to higher altitude. These instruments will not only reduce stress on infrastructure facility but also increase the environmental quality by reducing vehicular emission.

Development of traffic management and pollution monitoring mechanism at specific locations within the urban region needs to be given priority. This will lead to reduction of vehicular emissions with effective environmental monitoring facilities. Better traffic management and pollution check will help improve stakeholder's awareness. Traffic management initiative can be promoted

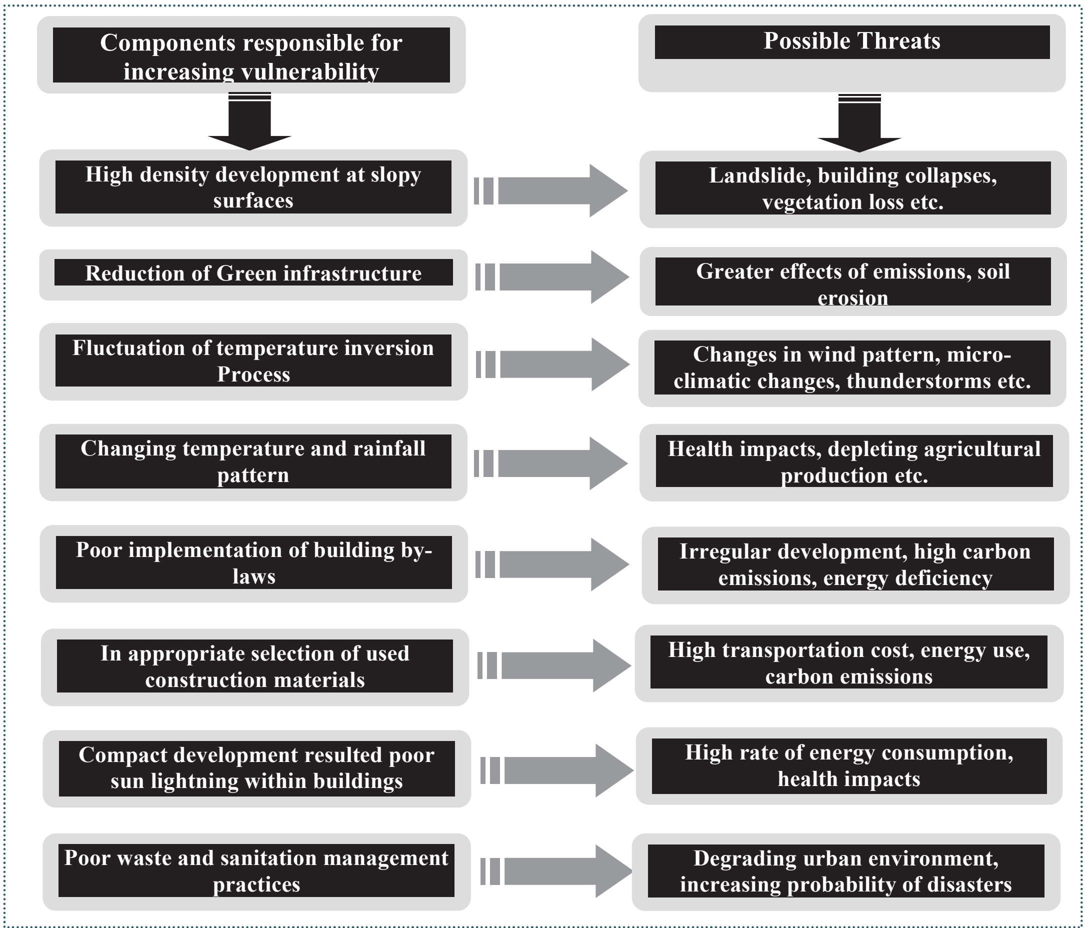


Figure 16. Emerging urban vulnerabilities- Gangtok

by involving the private sector through PPP Models.

Pedestrianisation and walkability is one of the key indicators of efficent city planning which help reduce emission and energy use. Along the busy roads especially in the central market areas improved pedestrianisation should be emphasised especially MG Marg, Ranipol crossing needs to be redesigned to facilitate walkways.

Conservation and improvement of green infrastructure in Gangtok needs to be undertaken immediately. Due to rapid construction and development the green spaces are depleating fast hence this intervention is the key to improve the urban environment and micro climate.

There are severall natural water outlets in the region which are mostly polluted with solid waste. Management of Jhoras and natual springs needs to be taken care by landscaping and increasing the green cover. This will reduce the scope of water pollution and choking of waste water drains as well as erosion and landslide. The carbon sink capacity will also increase.

Specific interventions have to be initialised for soil erosion and landslide management in the region which poses maximum threat for the communities. Terraced landscape, increasing green cover along steep slopes is possible options.

Solid and liquid waste management and recycling facility in Gangtok should be given priority for improvement in quality of urban environment. Use of renewable energy and low carbon technologies should be encouraged. Although these initi atives needs higher initial investments but are sustainable in the long run.

Figure 17. Public transport Innovation

Figure 18. Improved pedestrianisation

Sustainable local livilihood practices should be encouraged along with the promotion of vernacular construction and architectural tradition. Given the fact that construction is a mjor component of the economy and also the most environmentally regressive, appropriate and sustainable buidling techiniques should be seen as an alternative.

It is important however to remember that the specific action strategies are important in correcting environmental mismanagement in the short run, however in the context of increasing climate variability and urban vulnerability these measures will have to be integrated as a part of larger and long term policy and planning initiative. Moreover to be effective they have to be implemented in a holistic and integrated manner. Small piece meal and reactive adhoc measures will not be successful. In this context it is important to have state and city level policies and plans to integrate various projects to address the environmental and climate variability concerns. The following section provides an over view of possible policy and planning options which can be effectively implemented in Gangtok.

Figure 19. Development option for Jhora's

Figure 20. Promotion of low carbon solar energy

9. Existing urban and regional practices in Sikkim-Gangtok

Generally it is the Municipality that looks into the functions of the local service provisions and urban planning functions. In case of Gangtok, the Municipal Corporation Act was passed in 1975, but in 1985 the Act was repealed and the functions of urban local body were transferred to the state government. The Sikkim Municipal Bill 2006 has been finalized; in accordance with 74th constitutional amendment however implementation is weak because the local body is yet to become fully functional. The Urban Local Bodies still do not have power and capacity to undertake planning and management functions effectively.

The UD&HD has part administrative responsibility and legal jurisdiction to develop the city infrastructure and provision of services to its citizens. Other Government agencies like the PHED and PWD, Power, Transport have an independent charge of the operations relating to their function as a result there is clear lack of coordination between the Departments to address existing problem and growing needs. Multiplicity of institutions and poor urban planning practice has failed to internalize negative externalities and has increased vulnerabilities of the communities to different environmental risks.

Along with weak institutional framework the urban region of Gangtok has very poor environmental management practices. Although the region is located in a highly vulnerable zone still the City Development Plan prepared for Gangtok has not looked into the environmental issues and the mobility plan prepared for the region does not calculates the carbon footprints. These clearly suggest that the inclusion of environment and climate change mitigation and adaptation into mainstream urban planning process has not been considered. There is also no integration between the Land Use Plan (Development Plan) and the City Development Plan.

10. Options for internalizing environment and climate variability through mitigation and adaptation strategies in urban planning and management

The natural environment provides cities with countless ecosystem services. Some of these air, water, open space, are fundamental to urban livability. However they often seem invisible to urban managers as a result environmental resources are taken for granted instead of being utilized, enhanced, and invested in a sustainable manner. There is immediate need to internalize the negative externalities to minimize environmental and climate variability risk through appropriate mitigation and adaptation strategies. Under the present context of environmental degradation and climate change suitable adaptation and mitigation strategies needs to be formulated at the city level. Mitigation refers to all policies and measures aimed at reducing emissions of green house gases such as CO_2 or at capturing them at forests, oceans or underground reservoirs. Adaptation is the term used to describe all activities aimed at preparing for or dealing with the consequences of climate change, be it at the level of individual households, communities, firms or entire sectors and cities. Various experts have worked out various methods to formulate city level mitigation and adaptation framework. Few such alternatives have been suggested for Gangtok so that environment and climate change can be internalized in development programme. The following table provides an overview of planning practices in Gangtok urban region.

Table 7. A comparison between standards and existing governance practices in Gangtok

Interventions needs to be done by local authority	Existing practices
Dedicated Environment cell at the Municipal level to keep a view of the environmental change through constant monitoring	There is no separate agency for environmental monitoring and assessment within local body in Gangtok
City level environmental management and climate change action plan formulation	No environmental/climate change related plans have been prepared
Measurement of carbon foot printing and associated EIA measures	EIA and carbon foot printing measurement have not been exercised in Gangtok
Inclusion of environment and climate change concerns in land use and mobility planning instruments	The CDP prepared on 2006 has no analysis of environment and hence inclusion is neglected
Strict implementation of building by laws, regulation and codes	Very poor and inefficient implementation mechanism of implementing by laws and regulations
Awareness generation among residents and tourists through various strategies by various authorities	No city level awareness generation strategies have been formulated to combat with disasters
Multi Hazard Vulnerability Assessment	Not Existing

One can infer that the existing system is weak to tackle the emerging challenges of urbanization and climate change. Therefore inclusion of adaptation and mitigation strategies into mainstream urban and regional planning practices in Gangtok is important. Some relevant strategic intervention options are indicated in the following section.

Spatial/Regional environmental management plan in Gangtok urban region

Spatial planning at urban and regional level is one of the most important policy tools proposed for delivering sustainable development at local level (UNCHS, 1999). It will shape and influence many aspects of the area's development including economic, social and environmental. This instrument besides optimizing land use has important indirect potential to reduce the energy consumption, improve mobility patterns of the citizens by locating new development along existing public transport lines and promoting mixed used by providing residence, work and services in the same area. This can have a significant impact on reducing pollution and energy demand of the hill communities in the region.

Spatial environmental planning strategy in Gangtok should emphasize environmental content, strategic sustainable planning policy formulation and effective stakeholder participation. This vision should be accompanied by a range of planning action like avoiding urban sprawl and ensuring efficient and optimal use of land. Competing environmental, social and economic demands for limited space should be resolved through innovative high quality design of public space, buildings and infrastructure like the redesigned M.G. Marg. Planning at the regional level is important. It also internalizes the requirement of the 74th constitutional amendment act by institutionalizing the District Planning Committee (DPC).

Environmental profile & benchmarking for Gangtok region and other towns in Sikkim

The basic idea of this proposed exercise is to analyze the urban environment from sectoral perspective and identification of issues. All this leads to formulation of policies and proposals for environmental development and management. Although this is a time consuming and complex exercise however has the potential to help identify and address emerging issues of climate change and sustainable development.

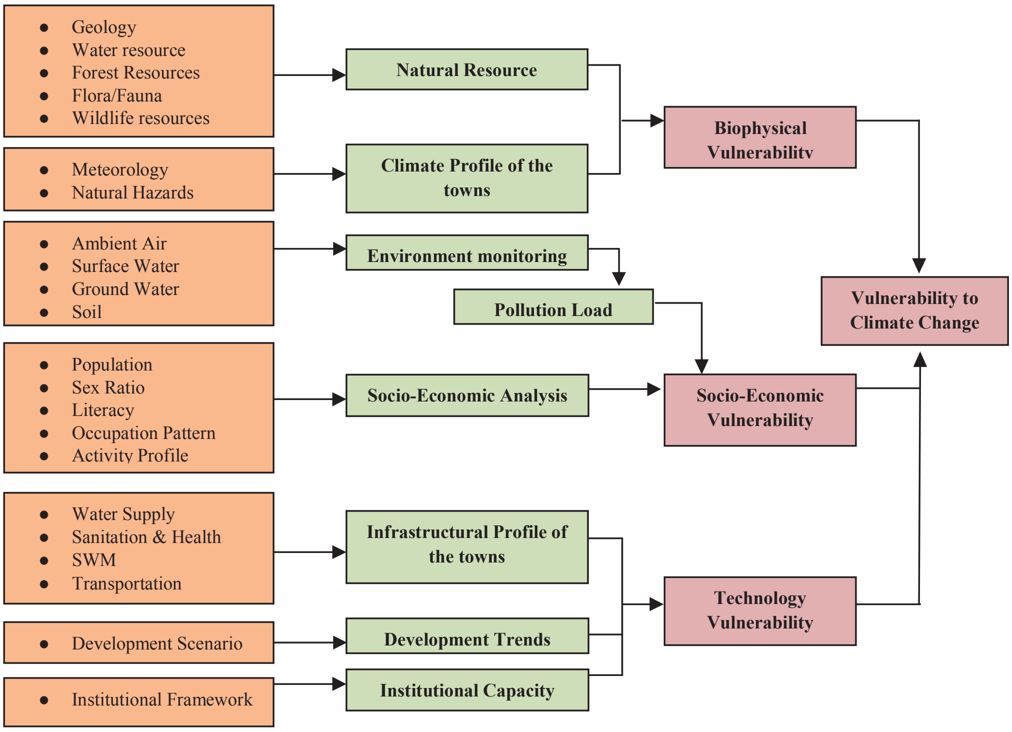


Figure 21. Proposed framework for environmental profile & benchmarking

The exercise can also be integrated with other strategic planning interventions like Eco City Planning, Strategic Environmental Assessment of the urban area and for formulating annual Environmental Status report. But in order to do these the local body will have to create a dedicated environmental cell and also build capacity of the local professionals.

Green infrastructure design framework in the hilly region

Development of green infrastructure can also be proposed to improve the urban environment, quality of life and reduce vulnerability. It helps promote and increase carbon sink. Green infrastructure is the physical environment within and between our cities, towns and villages. It is a network of multi-functional open spaces, including formal parks, gardens, woodlands, green corridors, waterways, street trees and open countryside (Davies et al, undated). It comprises all environmental resources, and thus a green infrastructure approach also contributes towards sustainable resource management. This design strategy also includes people's participation in managing green spaces.

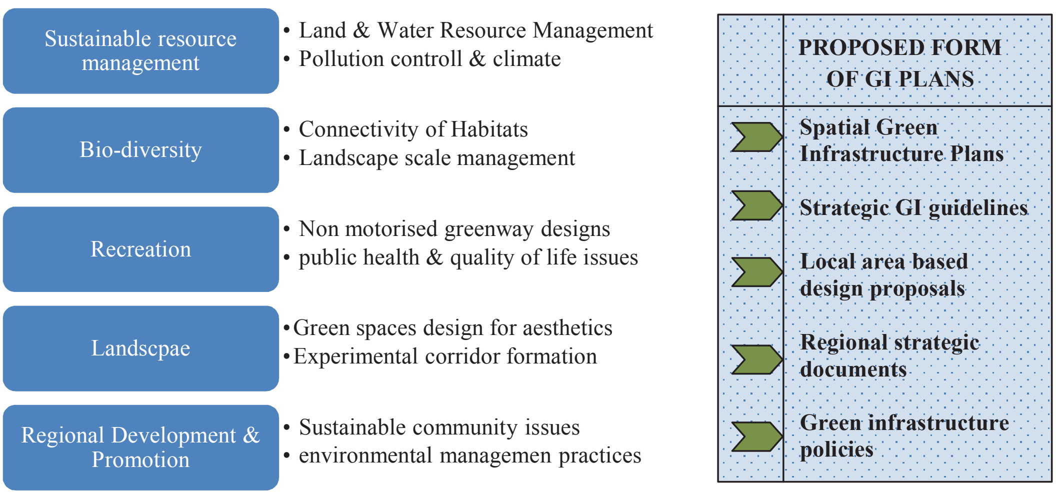


Figure 22. Framework and instruments for GI planning

Earthquake resistant green building by-laws, zonal regulations and DCRs for Gangtok

With available modern technologies construction of earthquake resistant green building should be promoted in both urban and rural areas. Green buildings are energy efficient, recycle and use waste, are often built with local materials thereby reducing the carbon footprints and are appropriate and sustainable. Green building offers a comprehensive set of best practices to design and construct efficient, healthy homes that benefit the community, the environment, and the people. Bye Laws, Zonal Regulation and Development Control Regulations can be formulated for earthquake resistant green building technology. Green building design evaluation system like LEED and GRIHA should be internalized in building codes and bye laws. The national sustainable habitat mission also intends to internalize these concerns in habitat planning exercise in the future (GoI, 2008).

Multi hazard vulnerability assessment

In an area like Gangtok which is affected by multiple hazards like landslides, earthquakes, cloud burst and other climate induced extreme events multi hazard vulnerability assessment should be the base for land use and regional planning exercise. This exercise incorporates microzonation of the urban settlements. Hazard Vulnerability/Risk management can be considered as an attempt to synchronize various natural hazards, (e.g. rapid mass movements, Flood, earthquake etc.) and manmade disasters characterized by the dimensions of time (e.g. seasonal appearance) and place. The purpose of multi-Hazard vulnerability assessment is basically to establish a ranking of the different types of risk taking into account possible cascade effects i.e. the situation for which an adverse event triggers one or more sequential events (synergistic event). Though Gangtok urban region is characterized by the presence of multiple natural risks in the form of earthquake, landslide etc. a, systematic consideration of multiple hazards for spatial planning still remains unanswered. Hence this technique should be adopted by decision makers (e.g., disaster management agencies, urban planners, and insurers, regional and local authorities) to provide comprehensive comparable information which includes all relevant hazards types within the region. Climate Change induced disaster and other risk scenarios can be internalized.

The procedure for multi-hazard risk assessment is indicated below:

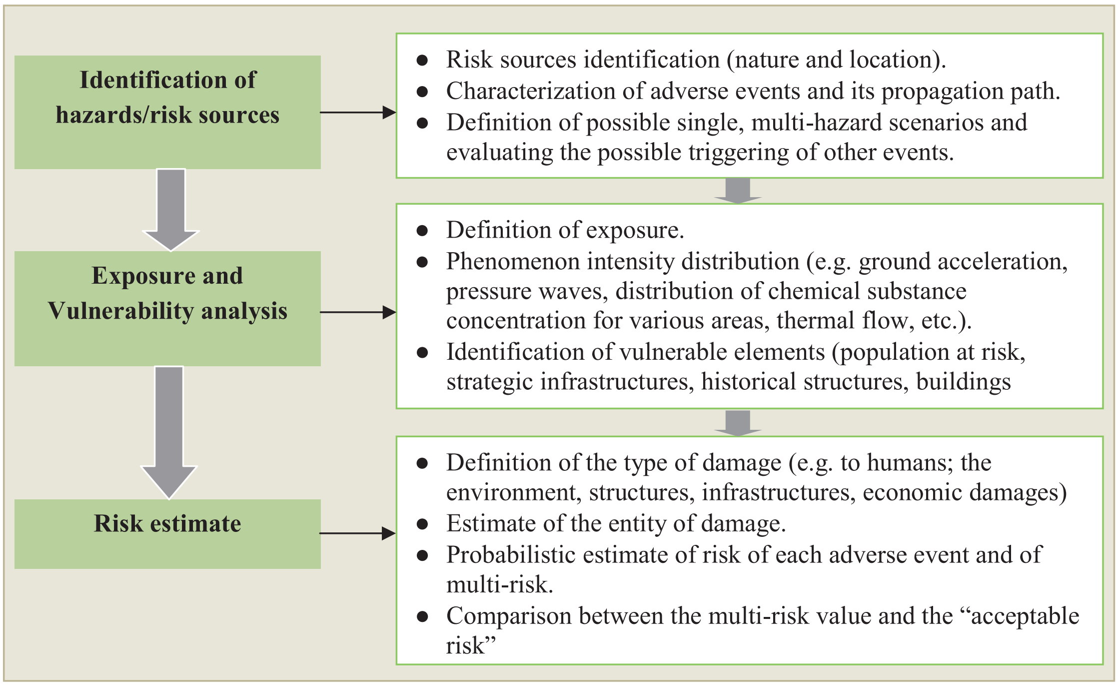
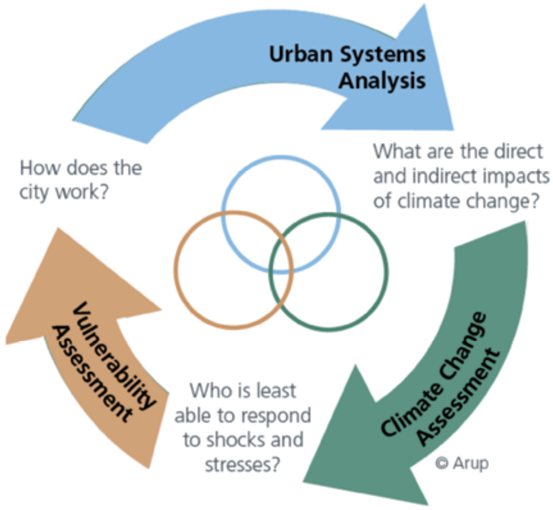


Figure 23. Proposed Multi Hazard Risk Assessment Methodology

City resilience strategy and local climate change adaptation framework

The ability to manage hazard risk especially climate variability and change risk depends on number of factors like the base line infrastructure and quality of services, resource linkages like water and energy, economic growth, poverty and employment opportunities, social safety nets, effective governance, investment on hazard mitigation and vulnerability reduction, access to information, collective stakeholder responsibility and public awareness (TARU, 2010). City Resilience is a continuous activity and its objective is to reduce impacts on the community especially the poor. It provides a framework and direction for economic



Source: ACCCRN, 2009

development and service delivery along with the coping and adaptation strategy by local government institutions and the community. In a way it is a participatory bottom up approach to meet the threats of disasters induced by climate variability and change. It is also a mechanism to improve governance by bridging the national, state and local level action plan. Good governance is critical for addressing climate change challenges in the city (Layzer, 2011, Satterthwaite, 2011). It is to be remembered that in the context of Gangtok adaptation needs to be given importance along with mitigation. Internalizing existing community adaptation strategies and innovating possible adaptation action plan for different sectors is a socially and economically feasible option than mitigation which at times can be costly beyond the reach of the individual and the local government.

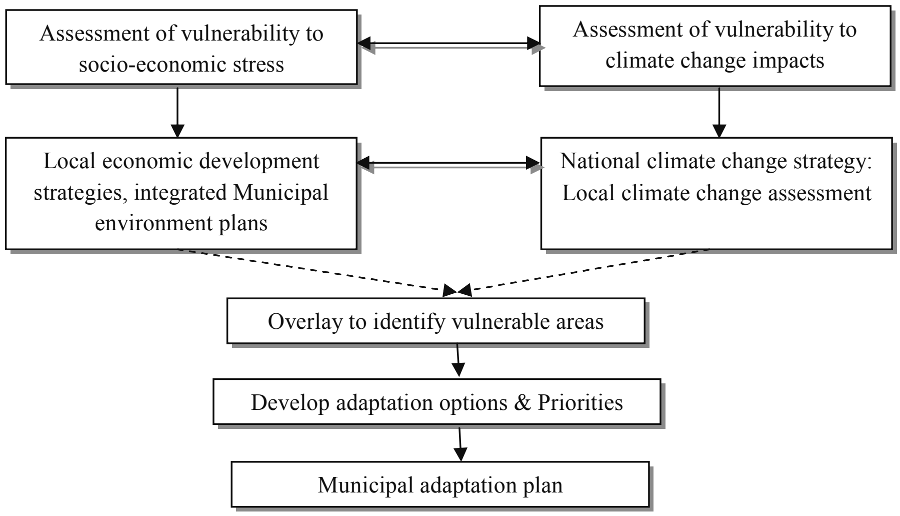


Figure 24. Climate change policy framework

Regional Cooperation and Integration

Given the fact that Climate Change and variability is a global and regional phenomenon it is important to network and share information and experiences across political boundaries to evolve effective strategies. Such initiatives have already been facilitated by the Rockefeller foundation in Asia which is called the Asian Cities Climate Change Resilience Network (ACCCRN). It is a network of ten cities in India, Indonesia, Thailand and Vietnam experimenting with a range of activities that will collectively improve the ability of the cities to withstand, to prepare for, and to recover from current and future impacts of climate change that are difficult to predict. ACCCRN represents a unique initiative to develop, test and demonstrate practical strategies for responding to the impacts of climate change on urban areas (www.acccrn.org). The ACCRN aims to catalyze attention, funding, and action on building climate change resilience for poor and vulnerable people by creating robust models and methodologies for assessing and addressing risk through active engagement and analysis of various cities. Such an initiative can also be started for the Himalayan cities by India, China, Bhutan, Nepal, Pakistan, and Afghanistan. Besides the Himalayan states other countries like Myanmar, Thailand, Vietnam could also be involved in the network. The Regional cooperation should involve local capacity building programmes, documentation of best practices, information exchange and E-learning initiatives. Such initiatives will facilitate transnational climate governance framework (Bulkeley and Newell, 2010) and institute like Sikkim University should take the lead in forming such forums.

11. Conclusions

It can be summarized that urbanization and associated environmental problems are critical for sustainable development of Gangtok urban region. Even without factoring the climate change and variability risks Gangtok and its hinterland is already vulnerable to multiple environmental problems like haphazard development, pollution, waste disposal, landslides, heat island effects and destruction of the green infrastructure. Climate change and variability will further accentuate the vulnerability and risk. Under such a situation planning only to mitigate and adapt climate risk without understanding the existing environmental problems may be incomplete. Strategies and techniques to asses multiple hazards and internalize vulnerabilities will have to be evolved. Environmental bench marking, preparation of urban and regional plans, green infrastructure development and city resilience strategies will have to be based on multiple hazard assessment. Specific urban design strategies and bye laws and development control regulations will have to internalize the multiple hazard concern. Mitigation which is often the prime focus of response to climate change is important but adaptation strategies are more critical. Adaptation strategies will have to take into account the traditional and community knowledge and coping strategies to create environmental and climate resilient communities. Experience all over the world has indicated that the ability to respond to the climate and environment induced changes will depend on community resilience and their preparedness. Regional and cross border collaboration between cities is important for sharing information, especially best practices, building capacities and preparing climate resilience and trans-frontier regional plans. Initiatives like the Mekong Delta regional plan involving the basin countries like China, Myanmar, Thailand, Lao PDR, Vietnam and Cambodia needs to be initiated with regards to the urban development and climate change concerns in the Himalayan states. Similarly initiatives like ACCCRN facilitated by the Rockefeller Foundation can also be thought of for the Himalayan cities. Such a collaborative strategy will go a long way in preparing the Himalayan states to face climate change concerns in the future. However such collaboration can happen when affected parties are willing to collaborate and there is availability of credible information. Most of our planning exercise fails because of weak information and data base. Planning for climate resilient cities will need much more detailed information. Therefore the first initiative of the collaborative efforts should be to document and create database across the region which can be used for scientific research and planning climate resilient cities of the future in the Himalayan region.

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Endnotes

1 Mean maximum temperature (°C) is defined by the average daily maximum air temperature, for each month and as an annual statistic, calculated over all years of record.

2 Mean minimum temperature (°C) is the average daily minimum air temperature observed during a calendar month and over the year.

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